

S
623.161 Kerr, Mark A
W3tws Toxicity of
1987 Water from Stanley
Creek and Fairway
Creek near
ASARCO's Troy
operation to

9/87

Montana Department of Health and Environmental Sciences
Water Quality Bureau
Cogswell Building
Helena, Montana 59620

Toxicity of Water
from Stanley Creek and Fairway Creek
near Asarco's Troy Operation
to *Ceriodaphnia*

Mark A. Kerr

September 1987

STATE DOCUMENTS COLLECTION

APR 22 1988

PLEASE RETURN

MONTANA STATE LIBRARY
1015 E. 6TH AVE.
HELENA, MONTANA 59620

Water Quality Management Series

MONTANA STATE LIBRARY
S 628.161 W3tws 1987 c.1 Kerr
Toxicity of Water from Stanley Creek and



3 0864 00060778 1

MONTANA STATE LIBRARY
1015 E. MAIN
HELENA, MONTANA 59620

Aug 24 1988

TOXICITY OF WATER
FROM
STANLEY CREEK AND FAIRWAY CREEK
NEAR
ASARCO'S TROY OPERATION
TO
CERIODAPHNIA

MARK A. KERR

State of Montana
Department of Health and Environmental Sciences
Water Quality Bureau
Cogswell Building
Helena, Montana 59620

September 1987



Digitized by the Internet Archive
in 2015

<https://archive.org/details/toxicityofwaterf1987kerr>

TABLE OF CONTENTS

	Page
TITLE PAGE.....	i
TABLE OF CONTENTS.....	ii
LIST OF TABLES.....	iii
LIST OF FIGURES.....	iv
ABSTRACT.....	v
ACKNOWLEDGEMENTS.....	vi
1. INTRODUCTION.....	1
2. OBJECTIVE.....	2
3. STUDY DESIGN.....	3
4. METHODS.....	7
4.1 Field Sampling.....	7
4.2 Chemical Analysis.....	7
4.3 Bioassay Procedure.....	7
5. RESULTS.....	9
5.1 Chemical Analysis.....	9
5.2 Bioassay Results.....	9
6. DISCUSSION.....	14
7. CONCLUSIONS.....	17
8. LITERATURE CITED.....	18

LIST OF TABLES

	Page
1. Total recoverable (TR) metals' concentrations and hardness values for waters collected from Fairway Creek (FC) and Stanley Creek (SC) on March 26, 1987 and May 6, 1987, and acute (1-hour) and chronic (4-day) criteria for the protection of aquatic life.....	5
2. Reproduction and survival data for days 3 through 7 for reconstituted water and water collected from Fairway Creek and Stanley Creek on March 26, 1987 and May 6, 1987.....	10
3. Total number of young produced per test organism for reconstituted water (Recon) and water collected from Fairway Creek (FC) and Stanley Creek (SC), March 26, 1987 and May 6, 1987.....	11
4. Student's t-values testing for differences in average reproduction comparing all pairs of test waters.....	13

LIST OF FIGURES

	Page
1. Water sampling locations on Fairway Creek (FC) and Stanley Creek (SC).....	4

ABSTRACT

Water was collected from three locations on Fairway Creek and Stanley Creek near Troy, Montana and tested to determine whether sediment and associated heavy metals from a fill slope below the ASARCO, Inc. copper/silver mill were causing toxic conditions in Stanley Creek. Water was collected before and during spring runoff. Ceriodaphnia dubia was the test organism used in a seven-day survival and reproductivity bioassay.

Fairway Creek, a tributary of Stanley Creek, was the designated control. Upper Stanley Creek adjacent to the mine/mill complex was the "point source" of pollution and lower Stanley Creek, downstream of Fairway Creek, was the impact zone. Reproduction in samples collected before and during runoff was compared to test for spatial and temporal changes in toxicity. Significant differences occurred in two comparisons. Reproduction was significantly lower in water collected from upper Stanley Creek before runoff than in water collected during runoff or in water from Fairway Creek. However, waters from lower Stanley Creek were neither more nor less toxic to Ceriodaphnia than water from Fairway Creek.

Waters collected during runoff, which had higher concentrations of heavy metals and greater and more numerous exceedences of water quality criteria than waters collected before runoff, were not more toxic to Ceriodaphnia than waters collected before runoff. Water collected from lower Stanley Creek before runoff, which had no exceedences of water quality criteria, was neither more nor less toxic to Ceriodaphnia than water collected from upper Stanley Creek during runoff, which had the most and severest criteria exceedences. Because reproductive success did not seem to depend on the number and severity of exceedences of water quality criteria, it might be concluded that reproduction responded more to the combined natural and artificial diet of the organisms than to concentrations of heavy metals. The depressed reproduction observed in water from upper Stanley Creek before runoff may also have been caused by some toxicant other than heavy metals. The data also suggest that metals were complexed or speciated in relatively non-toxic forms and that water quality criteria are conservative.

ACKNOWLEDGEMENTS

The author would like to thank Gary Ingman and Erich Weber of the State of Montana Water Quality Bureau for their suggestions concerning the study design and their collection of test water samples.

1. INTRODUCTION

The monitoring of Stanley Creek by the Montana Water Quality Bureau (MWQB) since the completion of the copper/silver mine and mill complex near Troy, owned and operated by ASARCO, Inc., has documented elevated concentrations of heavy metals in the stream during high flow events and in sediments below the mill site (Weber 1987). In October 1985, MWQB conducted a bioassay using Ceriodaphnia dubia to test waters collected upstream and downstream of the mill site on Stanley Creek and downstream of the tailings pond on Lake Creek. None of the waters tested proved to be toxic, although acute and chronic criteria for copper for the protection of aquatic life were exceeded in Stanley Creek below the mill (Kerr 1987). Because test waters had been collected during low flow, the report recommended a retest using water collected during higher flows when suspended sediment and associated concentrations of heavy metals would be greater.

In July 1987 another bioassay using Ceriodaphnia dubia was conducted by MWQB. The scope of the study was more limited, focusing on impacts of runoff from the mill site and erosion of the mill's fill slope along Stanley Creek. Potential impacts of the tailings pond on Lake Creek were not retested. Water was collected in late March before runoff and again in early May during runoff. The study design permitted the determination of downstream changes in toxicity, as well as same-site changes in toxicity related to flow conditions.

2. OBJECTIVE

The objective of this study was to determine whether heavy metals in upper Stanley Creek, derived from non-point source runoff from the mill site and erosion of the mill's fill slope along Stanley Creek, were causing toxicity in lower Stanley Creek. Toxic effects, measured by the survival and reproductive success of Ceriodaphnia dubia, would be related to concentrations of heavy metals and to water quality criteria for the protection of aquatic life.

3. STUDY DESIGN

The mill for the ASARCO/Troy mine is located on Stanley Creek above its confluence with Fairway Creek (Figure 1). The Fairway Creek drainage is relatively undisturbed, and is not impacted by mining activity in the area. Elevated concentrations of heavy metals, originating from non-point sources and erosion of the mill's fill slope, have been documented in water and sediment samples from locations in Stanley Creek upstream and downstream of the mill site and in water samples upstream and downstream of its confluence with Fairway Creek (Weber 1987).

The bioassay conducted in October 1985 used water collected upstream of the mill as the control and water collected downstream of the mill as test water in determining whether metals entering Stanley Creek from the mill site were creating toxic conditions. This bioassay considered the question of whether metals in upper Stanley Creek adjacent to the mill site were causing toxicity in lower Stanley Creek downstream of Fairway Creek. Essentially, this latter reach of Stanley Creek was being considered a continuation of Fairway Creek with upper Stanley Creek a "point source" of pollution. Fairway Creek, therefore, was established as the control (FC-1), with Stanley Creek above Fairway Creek (SC-17) and Stanley Creek below Fairway Creek (SC-2) as test waters. An increase in mortality, or an impairment of reproduction of Ceriodaphnia at SC-2, compared to FC-1, would indicate toxicity originating in upper Stanley Creek.

Two sets of samples, one representing pre-runoff, low-flow conditions and one representing high-flow conditions during runoff, were collected to determine whether toxic conditions existed in Stanley Creek during high flow because of the mobilization of sediment and sediment-bound metals. Water quality data (Table 1) indicated that concentrations of metals were higher in samples collected on May 6 during runoff than in samples collected March 26 before runoff, and that water quality criteria for the protection of aquatic life had been exceeded.

No precise methodology exists for comparing the relative toxicity of waters collected at one sampling location

Figure 1. Water sampling locations on Fairway Creek (FC) and Stanley Creek (SC).

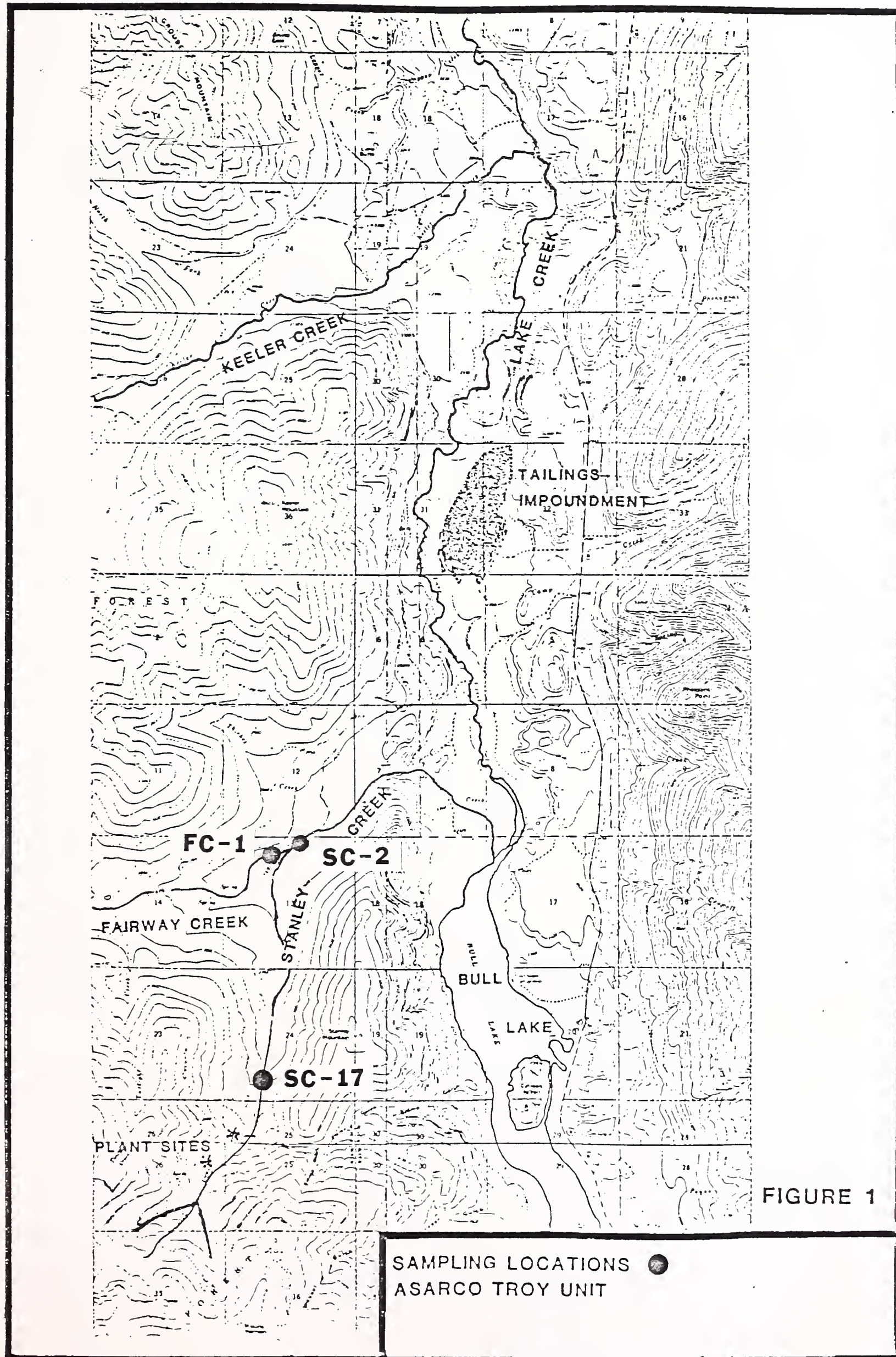


FIGURE 1

Table 1. Total recoverable (TR) metals' concentrations and hardness values for waters collected from Fairway Creek (FC) and Stanley Creek (SC) on March 26, 1987 and May 6, 1987, and acute (1-hour) and chronic (4-day) criteria for the protection of aquatic life. Instream concentrations as percentages of criteria are given in parentheses where criteria have been exceeded.

Test Solution	Concentration Parameter	Hardness mg/L as CaCO ₃	Cd ug/L	Cu ug/L	Pb ug/L	Ag ug/L	Zn ug/L
Fairway Creek (FC-1) 5/6/87	Instream	32.6	1.7	<1	1	<0.2	22
	Acute	--	1.11 (153)	6.17	19.9	0.59*	45.3
	Chronic	--	0.47 (362)	4.54	0.78 (128)	--	41.0
Stanley Creek above Fairway Creek (SC-17) 3/26/87	Instream	24.0	0.1	5	<1	<0.2	9
	Acute	--	0.78	4.62 (108)	13.27	0.35*	34.9
	Chronic	--	0.37	3.49 (143)	0.52	--	31.6
Stanley Creek above Fairway Creek (SC-17) 5/6/87	Instream	11.7	0.6	14	3	<0.2	14
	Acute	--	0.35 (171)	2.35 (596)	5.46	0.10*	19.0
	Chronic	--	0.21 (286)	1.89 (741)	0.21 (1429)	--	17.2
Stanley Creek below Fairway Creek (SC-2) 3/26/87	Instream	28.0	<0.1	<1	<1	<0.2	5
	Acute	--	0.93	5.34	16.15	0.45*	39.8
	Chronic	--	0.42	3.98	0.63	--	36.0
Stanley Creek below Fairway Creek (SC-2) 5/6/87	Instream	25.7	0.8	5	1	<0.2	7
	Acute	--	0.85	4.93 (101)	14.8	0.39*	37.0
	Chronic	--	0.39 (205)	3.70 (135)	0.58 (172)	--	33.5
Fairway Creek** (FC-1) 3/26/87	Instream	29.0	<0.1	<1	<1	<0.2	6
	Acute	--	0.97	5.52	16.89	0.48*	41.0
	Chronic	--	0.43	4.11	0.66	--	37.1

* Values not to be exceeded at any time.

** Analysis of water used for culturing Ceriodaphnia given for comparative purposes only.

over a period of time. One reason is that current methodology emphasizes spatial changes in toxicity resulting from a discharge or cumulative non-point sources rather than temporal changes related to flow conditions, seasonal effects, or cumulative impacts. Another reason is that many toxicants are not persistent and may degrade to non-toxic concentrations or compounds shortly after collection of a sample. For this reason, it is recommended that samples be held no longer than seventy-two hours before testing.

After collection, test waters were kept frozen for several months until used in the bioassay. Although this violated the recommended seventy-two hour holding time, the degradation of toxicity related to heavy metals was not believed to be highly probable. This permitted determinations of both spatial and temporal toxicity in Stanley Creek.

4. METHODS

4.1 Field Sampling

Waters for bioassay testing were collected on March 26 and May 6 in one-gallon polyethylene cubitainers. Samples were kept cold until returned to the laboratory. They were then kept frozen until several days before the start of the bioassay.

Samples for analysis of trace metals were collected in polyethylene bottles rinsed with Ultrex*, which was also used for preserving the samples. Samples for hardness were collected in unused polyethylene bottles and preserved with nitric acid.

4.2 Chemical Analysis

Water samples were analyzed for hardness and total recoverable cadmium, copper, lead, silver, and zinc. Hardness was analyzed by the State of Montana Chemistry Laboratory Bureau of the Department of Health and Environmental Sciences, using Inductively-Coupled Plasma Emission Spectroscopy (ICPES). Total recoverable metals (field acidified to pH<2.0 and settled) were analyzed by Energy Laboratories in Billings using carbon furnace atomic absorption spectroscopy.

4.3 Bioassay Procedure

Ceriodaphnia were obtained in April 1987 from cultures maintained by U.S. Environmental Protection Agency (EPA) in Denver. Continuous cultures were subsequently maintained by MWQB. On June 25, three weeks before the start of the bioassay, cultures using water collected from Fairway Creek on March 26 were started to acclimate Ceriodaphnia to the control. This culture was maintained according to recommendations of the U.S. EPA (1985). One week before the start of the bioassay, brood parents from this culture were isolated in individual beakers containing water collected from Fairway Creek on May 6. Brood parents were fed daily and transferred to fresh water every other day until the start of the bioassay.

* Ultrex is the trademark name for ultra-pure nitric acid.

The bioassay began on July 16. Neonates between four and eight hours old were placed singly into 30-ml disposable plastic test beakers containing 15 ml of test water. For each test water except the control, ten replicates were used. For the control, two sets of ten replicates were used as a quality control measure. Each day for the next six days, test organisms were transferred to beakers containing fresh test water and were fed 0.1 ml of a prepared food containing dried cereal leaves, yeast, and trout chow. Mortality was noted during the transfer and reproduction was tabulated immediately thereafter.

Two sets of reconstituted water were also tested. Reconstituted water is prepared using distilled/deionized water and NaHCO_3 , $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$, MgSO_4 , and KCl . A hardness of 30 mg/L as CaCO_3 in the reconstituted water approximated the hardness of most of the stream waters tested and was included to demonstrate that the prepared food was adequate to promote acceptable reproduction (15 neonates for three broods in the reconstituted water). A second reconstituted water of hardness approximating 10 mg/L was included because the hardness of Stanley Creek above Fairway Creek during runoff was 11.6 mg/L. Ceriodaphnia have been known to reproduce poorly in very soft water. Had a toxic response occurred in water collected from SC-17 on May 6, the use of a very soft synthetic water would have been useful in determining whether the response was related to exceedences of water quality criteria or to the softness of the water.

Test beakers were incubated at $25^\circ \pm 1^\circ\text{C}$ in a Lab-Line Ambi Hi-Lo Chamber, and were capped with plastic lids to prevent evaporation caused by the air circulation blower in the incubator.

5. RESULTS

5.1 Chemical Analyses

Results of analyses for total recoverable metals are summarized in Table 1. Hardness values are also included, as are acute (one-hour) and chronic (four-day) criteria recommended by the U.S. EPA (1986, 1987) for the protection of aquatic life.

Two trends were observed. Waters collected from the two sites on Stanley Creek were softer during runoff (May 6) than before runoff (March 26). Also, concentrations of heavy metals in waters collected during runoff were higher than in waters collected before runoff (except for silver, which was never greater than the detection limit of 0.2 ug/L). These trends were not unexpected because of the relative purity of snowmelt which dilutes hardness during runoff and because of the increased potential of the stream to erode and carry metals-laden sediments during higher flows of runoff.

Also, water from Fairway Creek, a stream not known to have mining-related impacts, contained higher concentrations of cadmium and zinc during runoff than did either of the waters from Stanley Creek. These concentrations would have to be presumed natural unless some anthropogenic source is located.

Exceedences of acute and chronic criteria were more common during runoff than before runoff. The only test water which did not exhibit a criterion exceedence was the one collected from SC-2 before runoff. The greatest exceedences occurred at SC-17 during runoff. The lead concentration (3 ug/L) was more than fourteen times (1429%) the chronic criterion of 0.21 ug/L. The copper concentration (14 ug/L) was almost six times (596%) the acute criterion of 2.35 ug/L and more than seven times (741%) the chronic criterion of 1.89 ug/L.

5.2 Bioassay Results

Data on survival and reproduction are summarized in Tables 2 and 3. No mortality occurred in any water tested. All but two reproducing organisms released the three broods expected during a seven-day test. Reproduction was poorest in the

Table 2. Reproduction and survival data for days 3 through 7 for reconstituted water and water collected from Fairway Creek and Stanley Creek on March 26, 1987 and May 6, 1987.

Test Solution	Day No.	A	B	C	Replicate		F	G	H	I	J	No. of			Cumulative Avg.
					D	E						No. of Live Young	No. of Live Adults	No. of Young/ Live Adult	
Reconstituted Water Hardness 10 mg/L as CaCO ₃	3	0	0	0	0	0	0	0	0	0	0	0	10	0	0
	4	4	0	6	0	0	0	0	0	0	0	10	10	1.0	1.0
	5	7	0	9	0	0	0	0	0	0	0	16	10	1.6	2.6
	6	0	0	0	0	0	0	0	0	0	0	0	10	0	2.6
	7	9	0	11	0	0	0	0	0	0	0	20	10	2.0	4.6
Reconstituted Water Hardness 30 mg/L as CaCO ₃	3	0	0	0	0	0	0	0	0	0	0	0	10	0	0
	4	0	4	6	4	6	4	4	4	5	4	41	10	4.1	4.1
	5	6	8	6	6	6	6	6	5	6	6	61	10	1.6	10.2
	6	0	0	0	0	0	0	0	0	0	0	0	10	0	10.2
	7	9	8	8	9	9	7	6	8	11	9	84	10	8.4	18.6
Fairway Creek (FC-1) Replicate #1	3	0	0	0	0	0	0	0	0	0	0	0	10	0	0
	4	4	4	6	6	6	4	5	4	6	6	51	10	5.1	5.1
	5	10	8	10	10	7	8	9	8	10	7	87	10	8.7	13.8
	6	0	0	0	13	0	0	14	0	0	0	27	10	2.7	16.5
	7	14	12	16	0	12	13	0	13	14	12	106	10	10.6	27.1
Fairway Creek (FC-1) Replicate #2	3	0	0	0	0	0	0	0	0	0	0	0	10	0	0
	4	5	6	5	5	5	6	6	6	6	3	53	10	5.3	5.3
	5	8	8	9	6	8	9	10	8	8	8	82	10	8.2	13.5
	6	0	0	0	0	0	0	0	0	0	0	0	10	0	13.5
	7	13	12	12	13	13	11	12	15	11	11	123	10	12.3	25.8
Stanley Creek above Fairway Creek (SC-17) 3/26/87	3	0	0	0	0	0	0	0	0	0	0	0	10	0	0
	4	4	4	6	6	4	4	6	2	4	5	45	10	4.5	4.5
	5	5	9	10	8	6	7	9	9	9	6	78	10	7.8	12.3
	6	0	0	0	0	10	0	0	11	12	0	33	10	3.3	15.6
	7	9	14	15	11	0	9	13	0	0	7	78	10	7.8	23.4
Stanley Creek above Fairway Creek (SC-17) 5/6/87	3	0	0	0	0	0	0	0	0	0	0	0	10	0	0
	4	4	5	6	4	6	6	1	5	4	4	45	10	4.5	4.5
	5	11	9	8	10	9	8	11	10	10	10	96	10	9.6	14.1
	6	0	0	0	13	0	0	14	0	0	0	27	10	2.7	16.8
	7	16	11	13	0	13	13	0	14	11	13	104	10	10.4	27.2
Stanley Creek below Fairway Creek (SC-2) 3/26/87	3	0	0	0	0	0	0	0	0	0	0	0	10	0	0
	4	6	5	5	6	6	6	6	4	6	6	56	10	5.6	5.6
	5	7	5	10	9	10	8	9	10	10	9	87	10	8.7	14.3
	6	0	0	0	0	0	0	0	9	0	0	9	10	0.9	15.2
	7	11	13	14	12	16	11	16	0	14	12	119	10	11.9	27.1
Stanley Creek below Fairway Creek (SC-2) 5/6/87	3	0	0	0	0	0	0	0	0	0	0	0	10	0	0
	4	6	5	6	6	6	0	5	4	5	4	47	10	4.7	4.7
	5	11	7	11	11	12	11	11	8	10	7	99	10	9.9	14.6
	6	0	0	0	0	0	14	0	0	0	9	23	10	2.3	16.9
	7	15	12	15	14	13	0	14	11	12	0	106	10	10.6	27.5

Table 3. Total number of young produced per test organism for reconstituted water (Recon) and water collected from Fairway Creek (FC) and Stanley Creek (SC), March 26, 1987 and May 6, 1987.

Replicate (Organism)	Recon 10 mg/L Hardness as CaCO ₃	Recon 30 mg/L Hardness as CaCO ₃	FC-1 Rep.#1	FC-1 Rep.#2	SC-17 3/26/87	SC-17 5/6/87	SC-2 3/26/87	SC-2 5/6/87
A	20	15	28	26	18	31	24	32
B	0	20	24	26	27	25	23	24
C	26	20	32	26	31	27	29	32
D	0	19	29	24	25	27	27	31
E	0	21	25	26	20	28	32	31
F	0	17	25	26	20	27	25	25
G	0	16	28	28	28	26	31	30
H	0	17	25	29	22	29	23	23
I	0	22	30	25	25	25	30	27
J	0	19	25	22	18	27	27	20
Total	46	186	271	258	234	272	271	275
Average	4.6	18.6	27.1	25.8	23.4	27.2	27.1	27.5
Standard Deviation	9.80	2.27	2.69	1.93	4.77	1.81	3.31	4.30
Standard Error	3.10	0.72	0.85	0.61	1.51	0.57	1.05	1.36
95% Confidence Interval	<u>0.0</u> 11.6	<u>17.0</u> 20.2	<u>25.2</u> 29.0	<u>24.4</u> 27.2	<u>20.0</u> 26.8	<u>25.9</u> 28.5	<u>24.7</u> 29.5	<u>24.4</u> 30.6

reconstituted water having a hardness of 10 mg/L as CaCO_3 . Only two of the ten test organisms reproduced, and the average reproduction was 4.6 young per test organism (Table 3). Reproduction in the reconstituted water of hardness 30 mg/L was much better, and averaged 18.6.

Reproduction in all stream waters was good. The lowest average reproduction (23.4) occurred in water collected from SC-17 on March 26. The highest average reproduction (27.5) occurred in water collected from SC-2 on May 6.

Average reproduction in stream waters was compared statistically using the Student's t-test. Results were considered significant at the .05 level. All stream waters were compared to one another, even though a particular comparison might not be meaningful. Statistical results are presented in Table 4. Two comparisons were significantly different. Reproduction in water collected from SC-17 on March 26 was significantly lower than reproduction in one set of the control and in water collected from SC-17 on May 6.

Table 4. Student's t-values testing for differences in average reproduction comparing all pairs of test waters. The critical t-value for the $\alpha = .05$ level of significance is 2.101. A significant difference in reproduction is denoted by an underlined t-value.

	FC-1 Rep.#1	FC-1 Rep.#2	SC-17 3/26/87	SC-17 5/6/87	SC-2 3/26/87	SC-2 5/6/87
FC-1 Rep.#1	---	---	---	---	---	---
FC-1 Rep.#2	1.243	---	---	---	---	---
SC-17 3/26/87	<u>2.241</u> *	1.556	---	---	---	---
SC-17 5/6/87	0.098	1.671	<u>2.488</u>	---	---	---
SC-2 3/26/87	0.000	1.071	2.100	0.084	---	---
SC-2 5/6/87	0.249	1.140	2.088	0.203	0.233	---

* A t-test comparing SC-17 (3/16/87) to the pooled FC-1 replicates yielded a t-value of 2.458. Because the critical t-value for this test was 2.048, the difference in reproduction was significant. No other significant differences resulted from testing the other three Stanley Creek waters to the pooled FC-1 replicates.

6. DISCUSSION

This study was designed to determine whether water from Stanley Creek upstream of Fairway Creek was toxic or caused toxicity in the lower reach of Stanley Creek downstream of Fairway Creek. Fairway Creek was designated the control. Lower Stanley Creek could be considered an extension of Fairway Creek and upper Stanley Creek the "point" source of pollution which carries sediment and heavy metals derived from non-point sources and erosion of the mill's fill slope.

Hypothetically, toxicity might have occurred during low flow. Water quality data (Table 1) indicate that the acute and chronic criteria for copper were exceeded in upper Stanley Creek in samples collected before runoff. However, the contribution of Fairway Creek's cleaner, harder water resulted in no criteria exceedences in lower Stanley Creek. One anticipated result might be a toxic effect in water collected from SC-17 but not in water from SC-2. In fact, reproduction in water collected from SC-17 on March 26 was significantly lower than in one set of the control but not the other. However, a comparison made by pooling the two sets of controls confirmed that reproduction in water collected from SC-17 on March 26 was significantly lower than in water from Fairway Creek (Table 4). It should be concluded that water collected before runoff from upper Stanley Creek was more toxic to Ceriodaphnia than water from Fairway Creek, but did not cause toxicity in water from lower Stanley Creek.

This study was also designed to determine whether water collected during runoff was more toxic than water collected before runoff, and to determine whether upper Stanley Creek caused toxicity in lower Stanley Creek during runoff. Water collected during runoff could be more toxic than water collected before runoff, because of the lower hardness of snowmelt and the ability of higher and swifter flows to resuspend and remobilize sediment and associated heavy metals. Water quality data support this hypothesis. Waters collected during runoff from all sites were invariably softer, contained higher concentrations of heavy metals, and exceeded water quality criteria more frequently and

more severely than did waters collected before runoff. The only other statistically significant difference in reproduction occurred in waters from SC-17, where reproduction was higher in water collected during runoff than before runoff. This may be explained by a beneficially higher natural food source of bacteria and algae for Ceriodaphnia due to surface runoff and increased scouring during high flow. None of the data indicate the presence of toxicity in lower Stanley Creek or toxicity related to runoff.

The relationship between reproduction and water quality criteria is difficult to interpret. Water quality data in Table 1 suggest that the least toxic water would be from SC-2 on March 26 (no criteria exceedences) and the most toxic water would be from SC-17 on May 6 (greatest number of and severest criteria exceedences). However, there was no significant difference in reproduction in the two waters. In fact, the average reproduction was almost identical (27.1 and 27.2 young per test organism). Also, criteria exceedences were less severe and less frequent in water collected from SC-17 on March 26 than on May 6 or in the control. Yet, reproduction in this water was significantly less than in the other two. There are several possible reasons why reproduction did not relate well to concentrations of heavy metals or to the magnitude and number of criteria exceedences. One might be that metals were speciated or complexed in relatively non-toxic forms. Another might be that reproduction responded more to differences in the combined artificial and natural food sources than to metals' concentrations and criteria exceedences. Also, one or more unmeasured toxicants may have been present. Finally, criteria may be conservative enough so that small or infrequent exceedences do not result in toxicity to some aquatic species.

Reproduction and survival in the two reconstituted waters were important for several reasons. Reproduction in the water which had a hardness of approximately 30 mg/L indicates that the artificial diet was sufficient to promote acceptable reproduction in any test water deficient in a natural food

source. The very poor reproduction in the water which had a hardness of approximately 10 mg/L is consistent with other researchers' observations which indicate that Ceriodaphnia do not reproduce well in very soft water (telephone conversation 1988 January 11 with Del Nimmo, Aquatic Biologist, Denver, Colorado.) However, reproduction in the softest stream water (SC-17, May 6), which had a hardness of 11.7 mg/L, was very good. This indicates that the natural food source in this water may have been very high, or that the reconstituted water was deficient in some trace metal or nutrient necessary for the growth of Ceriodaphnia.

7. CONCLUSIONS

The data from this bioassay do not indicate that water collected from Stanley Creek downstream of its confluence with Fairway Creek was any more or less toxic to Ceriodaphnia than water from Fairway Creek, at the times and under the conditions which existed when waters were collected. Water collected from upper Stanley Creek before runoff was more toxic than water collected during runoff and was more toxic than water from Fairway Creek. The fact that reproductive success did not appear to depend on the number and severity of criteria exceedences suggests that a more important influence could have been differences in the combined natural and artificial diet of the test organisms. Metals may have been speciated or complexed in non-toxic forms, and some unmeasured toxicant may also have been present. Finally, water quality criteria for the protection of aquatic life are probably conservative.

8. LITERATURE CITED

- Kerr, Mark. 1986. ASARCO/Troy Ceriodaphnia bioassay. Unpublished report. Montana Department of Health and Environmental Sciences, Environmental Sciences Division, Water Quality Bureau. Helena, Montana.
- U.S. EPA (U.S. Environmental Protection Agency). 1985. Methods for estimating the chronic toxicity of effluents and receiving waters to freshwater organisms. Office of Research and Development, Cincinnati. EPA-600/4-85-014.
- U.S. EPA (U.S. Environmental Protection Agency). 1986. Quality criteria for water 1986. Office of Water Regulations and Standards, Washington, D.C. EPA 440/5-86-001.
- U.S. EPA (U.S. Environmental Protection Agency). 1987. Update #2 to "Quality criteria for water 1986". Office of Water Regulations and Standards, Washington, D.C.
- Weber, Erich. 1987. Metals and sediment pollution of Stanley Creek near ASARCO's Troy operation. Field investigation report. Montana Department of Health and Environmental Sciences, Environmental Sciences Division, Water Quality Bureau. Helena, Montana.

